EUVL Activities in Korea

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Who are interested in EUVL ?

Device manufacturer and material supplier
- **Samsung : NAND Flash, DRAM, High-end Foundry**
- **SK hynix: DRAM**
- **Kumho Petrochemical: Photoresist**

Academia and Research Institute
- **Hanyang Univ.: Mask, Pellcle, Cleaning, Metrology….**
  owns EUV beamline at Pohang Accelerator Laboratory
- **SKKU, Inha Univ., POSTECH…..**

Tool maker
- **Some small/med. size companies (e.g. FST, Auros tech) are developing EUV-related tools in collaboration with customers**

NXE: 3300B will be delivered …

Samsung (one in 2013, one in 2014) and SK hynix (2014) will receive their HVM from ASML with Cymer source

Insertion scenario …

Samsung

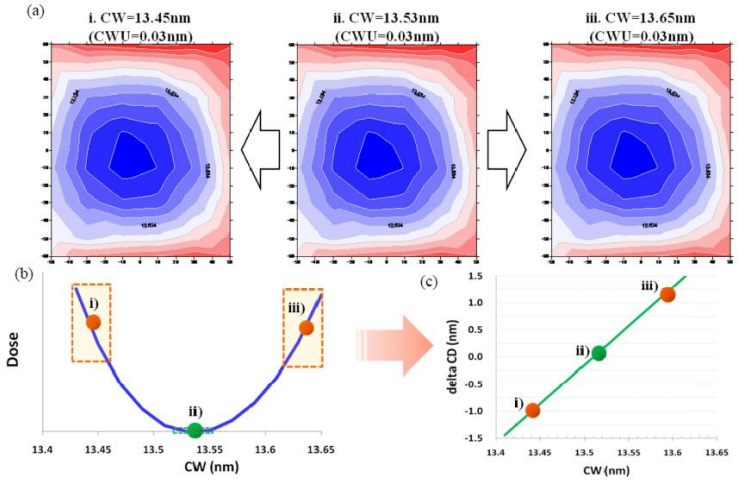
Samsung has the plan of EUVL insertion for 2Xnm node in mid-2014

Coherent scattering microscopy (CSM) is being manufactured, will be installed in 2014 2Q

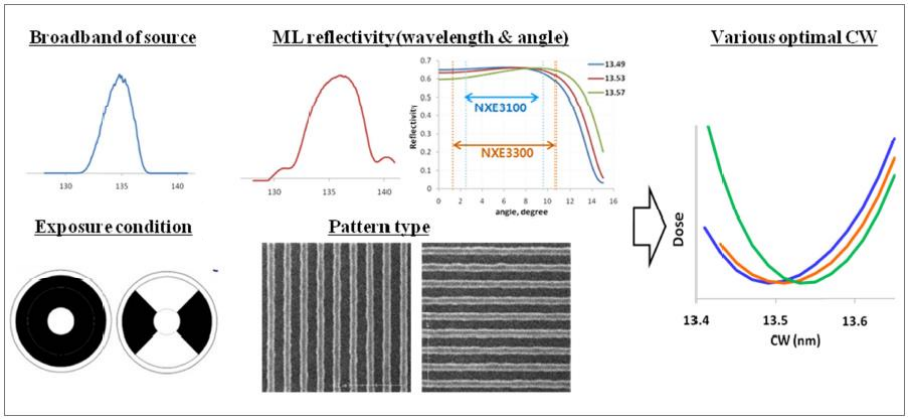
SK hynix

SK hynix has the plan of EUVL insertion for 1X nm node in late-2014 ~ 2016

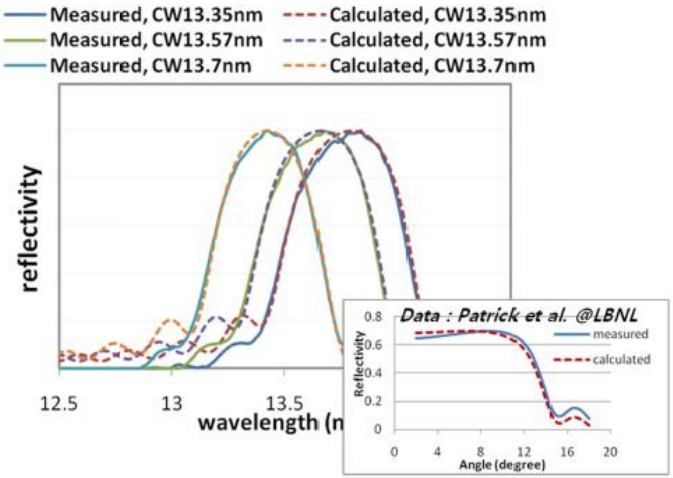
Effects of Mask CW (Samsung)



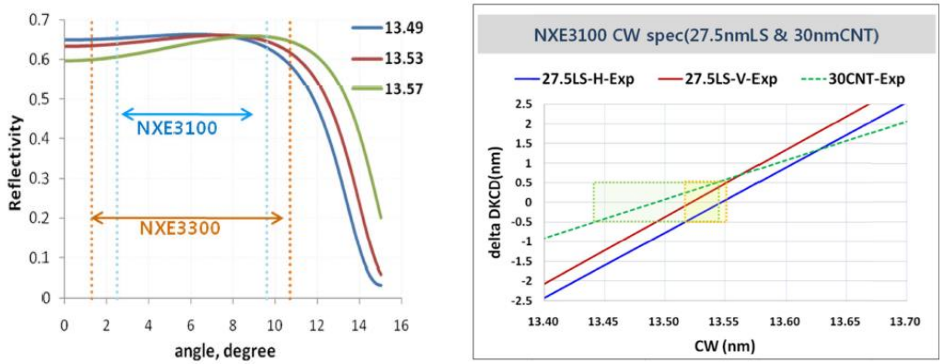
Influence of various center wavelength with constant CWU on wafer CD non-uniformity



Factors to affect on the optimal center wavelength

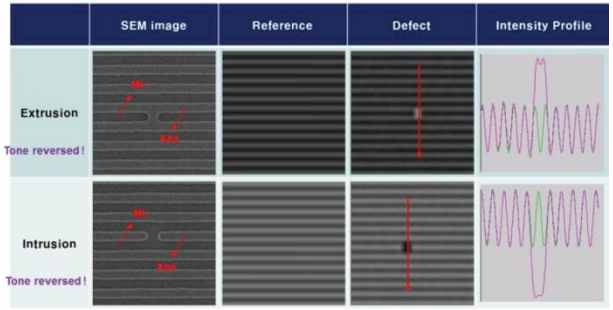


Multilayer reflectivity with calculation and measurement

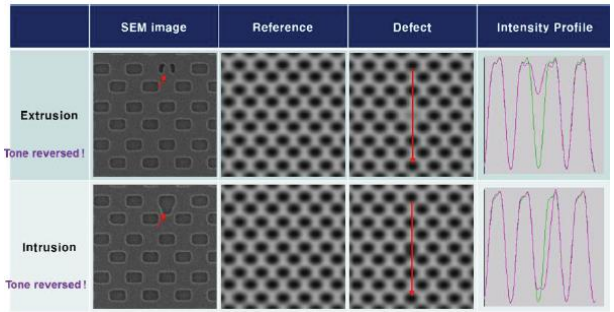


Investigated how the CW of ML affects wafer CD non-uniformity and verified the CW specification of ML by using purposely CW-shifted blanks

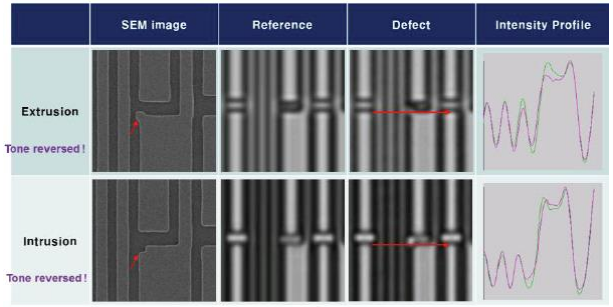
EUV mask inspection (Samsung)



Inspection image with bridge(extrusion) and cut(intrusion)
defect in 1:1 L/S of 2Xnm HP node



Inspection image with extrusion and intrusion defect in
dense CNT of 2Xnm HP



Inspection image with extrusion and intrusion defect in
isolated pattern of 2Xnm HP

2Xnm HP L/S		1	2	3	4	5	6	7	8	9	10	11	12
Extrusion	Printability								54nm	45.3nm	34.2nm	27.4nm	
	Die to Die	100%	100%	100%	100%	100%	100%	100%	100%	100%	72%	16%	
	Die to DB	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	40%	
Intrusion	Printability								49.8nm	39.2nm	34.1nm	22.6nm	
	Die to Die	100%	100%	100%	100%	100%	100%	100%	100%	100%	92%		
	Die to DB	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	44%	

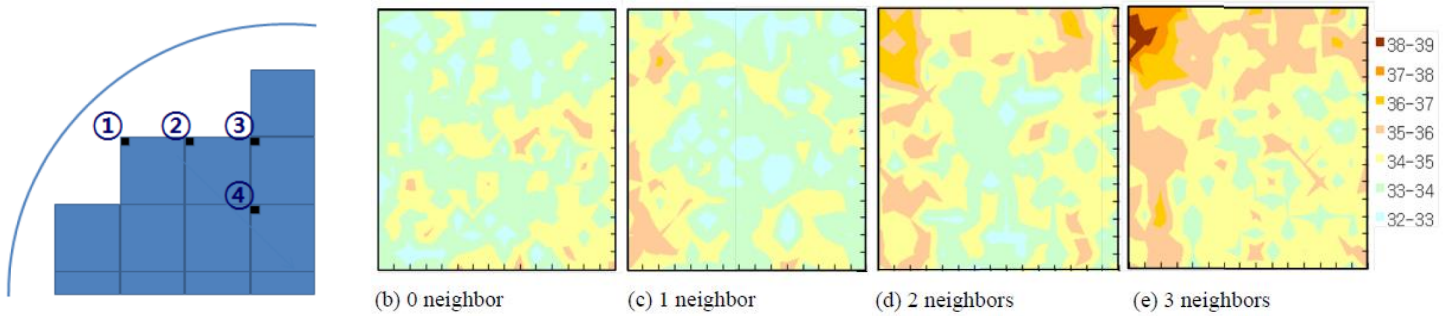
2Xnm HP CNT		1	2	3	4	5	6	7	8	9	10	11	12
Extrusion	Printability								54.1nm	42.4nm	38.3nm	36.9nm	25.2nm
	Die to Die	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	36%	
	Die to DB	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	36%
Intrusion	Printability								51.1nm	43.2nm	32.1nm	23.6nm	18.4nm
	Die to Die	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
	Die to DB	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	

2Xnm HP Iso. Pattern		1	2	3	4	5	6	7	8	9	10	11	12
Extrusion	Printability								44.8nm	43.2nm	40.8nm	37.1nm	
	Die to Die	100%	100%	100%	100%	100%	100%	100%	96%	92%	92%	80%	
	Die to DB	100%	100%	100%	100%	100%	100%	100%	100%	100%	96%	80%	
Intrusion	Printability								49.6nm	44nm	38.4nm	34.6nm	
	Die to Die	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	60%	
	Die to DB	100%	100%	100%	100%	100%	100%	100%	100%	16%			

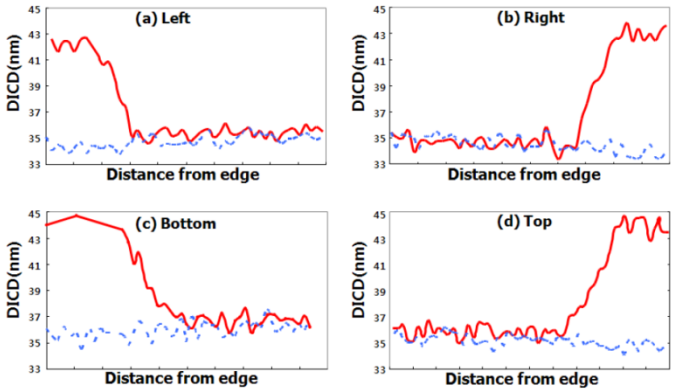
Sensitivity		L/S	CNT	Iso. Pattern
Extrusion	Die to Die	Bad	Bad	Good
	Die to DB	Good	Bad	Good
Intrusion	Die to Die	Good	Good	Good
	Die to DB	Good	Good	Bad
Tone reversal		Reversed	Reversed	Reversed
Readiness		OK	Insufficient	OK

Die-to-DB inspection has slightly more detectability than Die-to-Die. Unlike general optical mask inspection, specific optimal inspection condition exists at a given set of illumination condition, pattern size, and blank type for EUV's

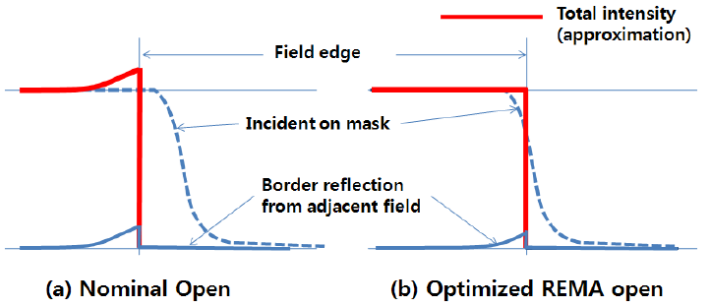
CD variation in the vicinity of exposure field edge (SK hynix)



Change of CD distribution of D2Y contact in upper-left corner of the field as a number of adjacent field changes



CD variation along four sides of the field when nominal set of REMA was applied to neighbor fields

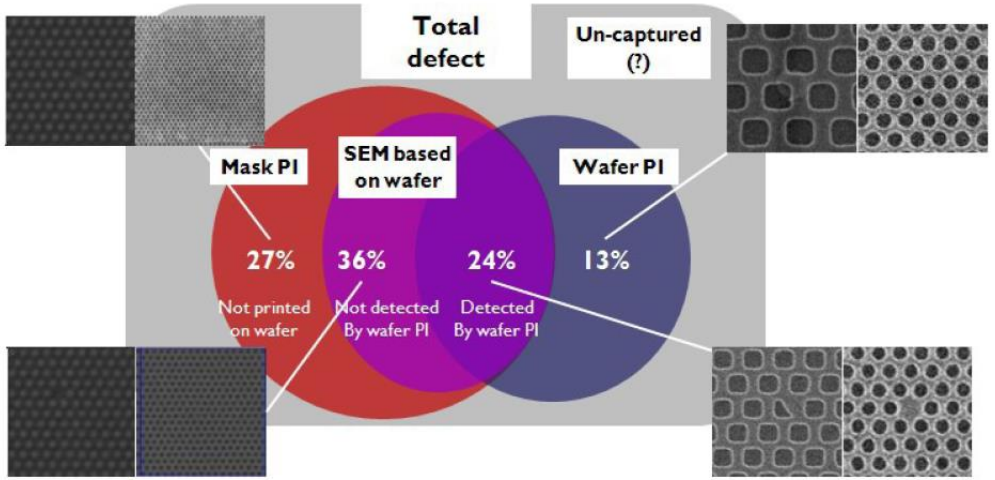


Total light intensity with respect to different REMA open settings

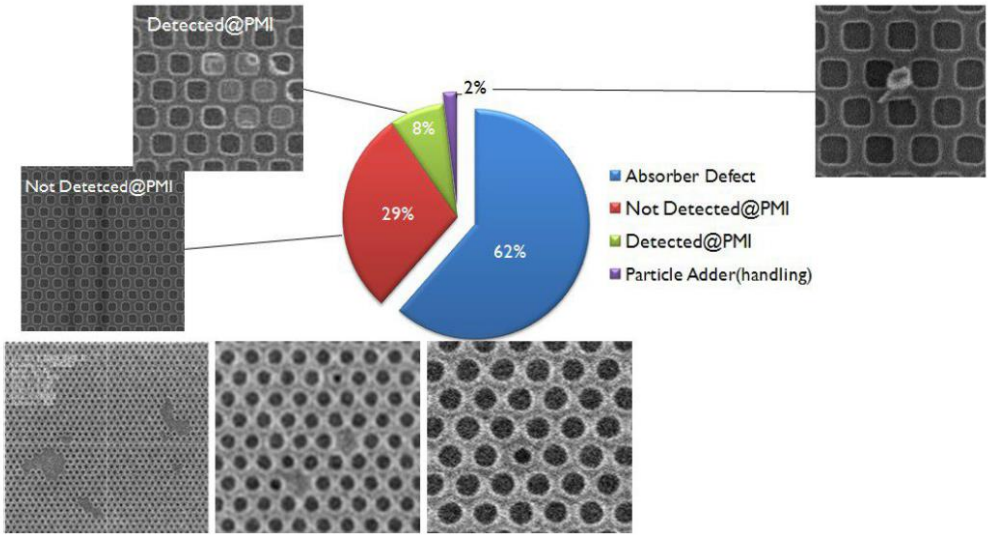
ReMa (Reticle masking blid: Framing blade) set optimization can be a makeshift solution in addition to well-known methods such as black border.

EUV mask defect analysis from mask to wafer printing (SK hynix)

EUV mask inspection route to improve mask defect inspectability



EUV mask defect status quo



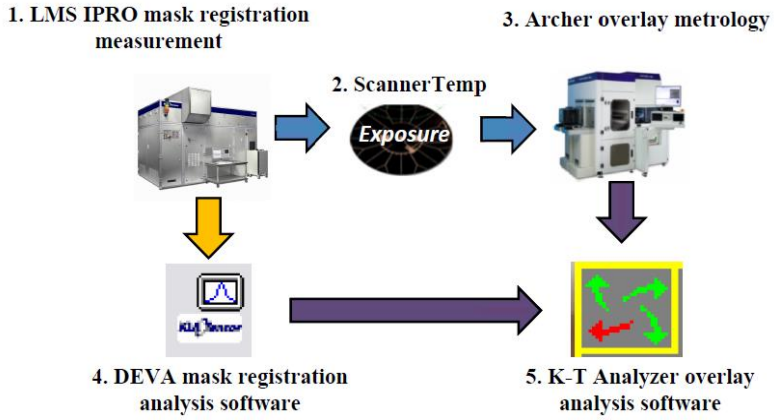
Printed defect analysis

A method to detect mask defect by inspecting printed wafer

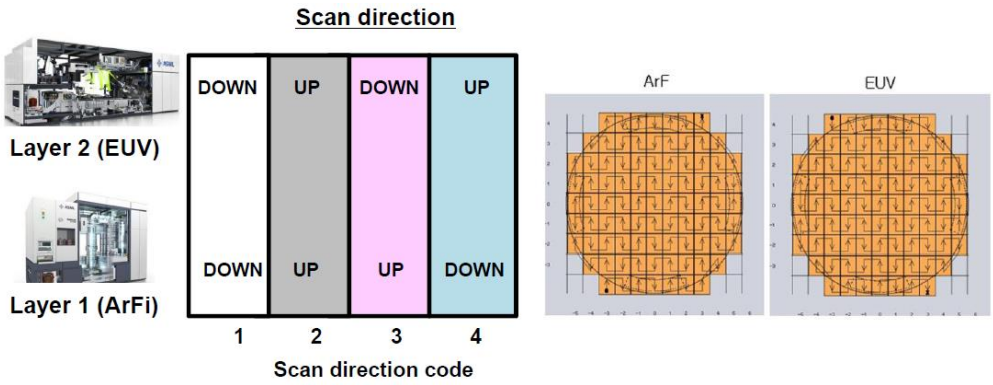
EUV mask defect status

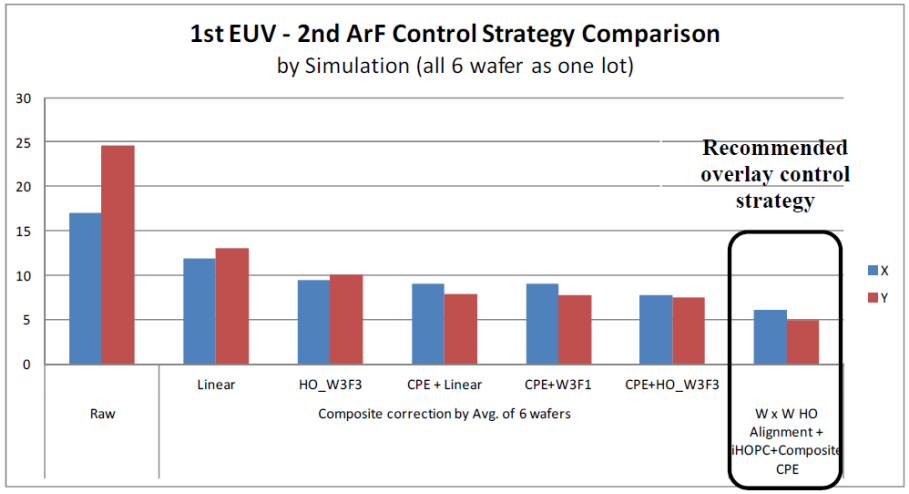
27% of defects are detected by mask inspection, but not printed on a wafer. 13% of defects are detected only by wafer inspection. 24% of defects are detected by mask inspection and wafer inspection. 36% of defects are detected by mask inspection and wafer SEM inspection. And there could be un-captured defects.

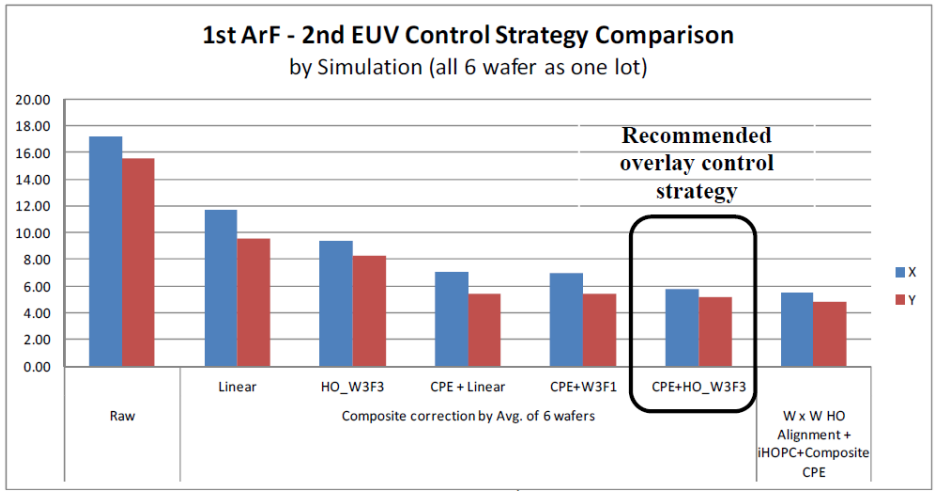
Overlay in EUV/ArF mix and match lithography (SK Hynix with KLA-tencor)



Experimental flow



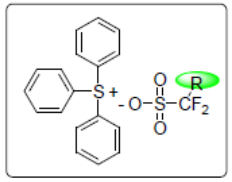




The mix-match overlay performance between ArFi and EUV scanners will be one of the key success factors in introducing EUVL for HVM at 1xnm node.

Acid amplifier in EUV resist material (Kumho Petrochemical)

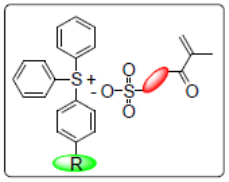
Table 1: Diffusion length(Ld) and coefficient(D) of blending type PAG



R	CF_3	$(CF_2)_3CF_3$	$(CF_2)_7CF_3$	A-cyclo hexyl	A-Adaman tane
Ld(nm)	155	79	48	88	59
D	200	52	19	64	29

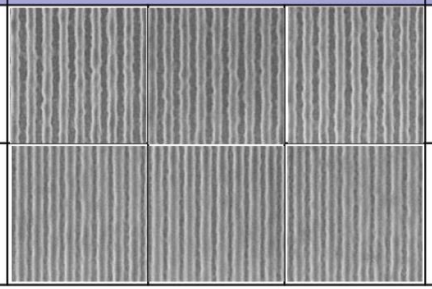
* SOB, PEB : 110°C/60sec * Development time : 40sec

Table 2: Diffusion length(Ld) and coefficient(D) of Polymer bound PAG



R	CH_3	t-Bu	cyclohexyl	long chain (C# >10)
Ld(nm)	18	17	23	5
D	2.6	2.4	4.3	0.2

* SOB, PEB : 110°C/60sec * Development time : 40sec

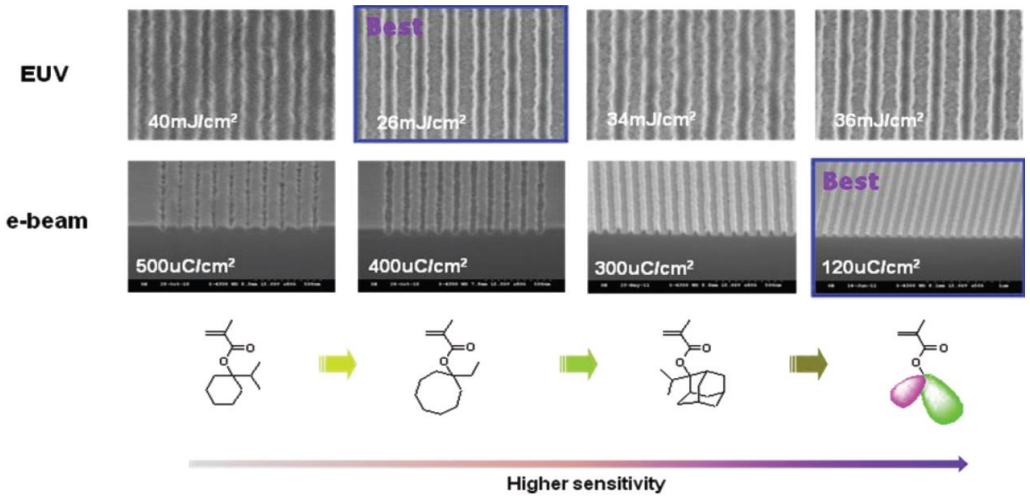
PAG	Resol.	Eop	CD-SEMimage	Remark
Blending type	40nm	13.3mJ		Severe bridge
PBP	40nm	28.2mJ		

The sensitivity comparison between blending type PAG and PBP in EUV light condition

LWR is related to acid diffusion of the photoacid generator

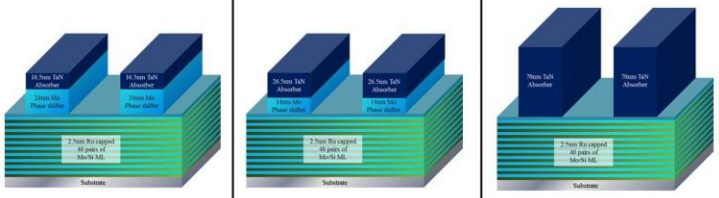
PBP (polymer bound PAG) type resist is decided as polymer platform because PBP type resist shows shorter acid diffusion length than blending type resist

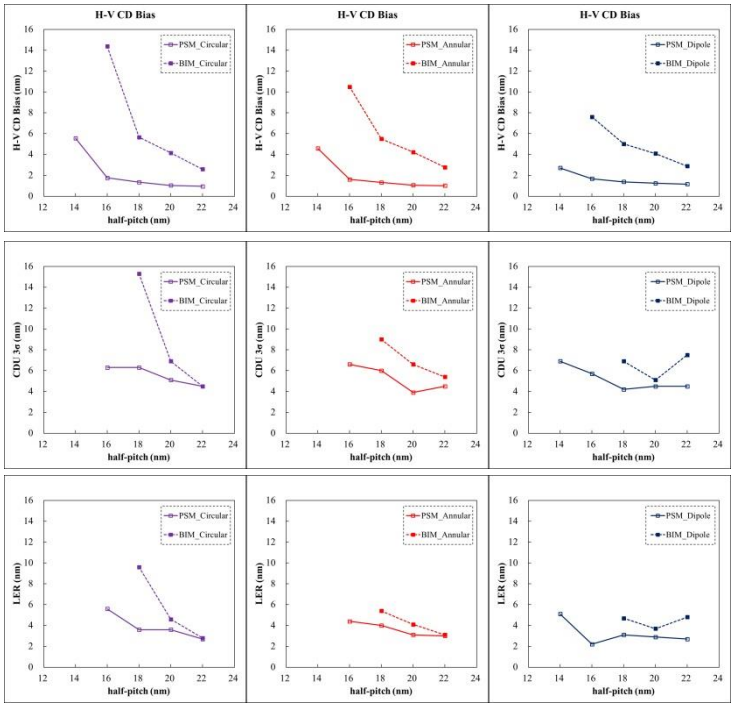
Acid amplifier, highly sensitive acid labile group in polymer and sensitizer are used for methods to improve sensitivity and LWR



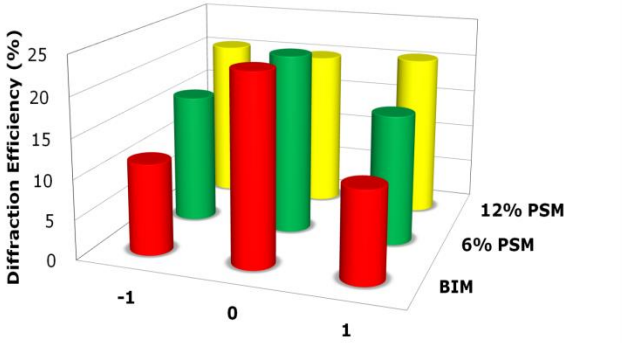
The Sensitivity comparison between EUV light and e-beam with acid labile group variation

PSN mitigation using PSM (Hanyang University)

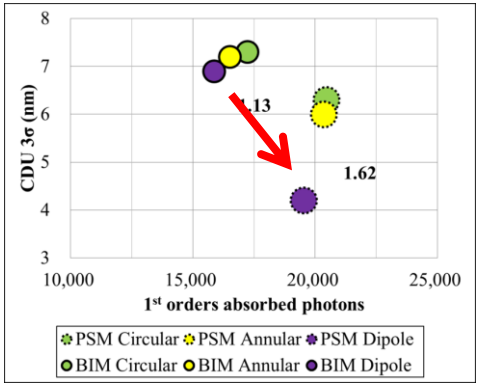
	12% PSM	6% PSM	BIM
Mask			
Absorber stack	16.5nm TaN / 24nm Mo	26.5nm TaN / 14nm Mo	70nm TaN
Reflectivity	12.66%	5.85%	0.18%
Phase difference	178°	180°	79°

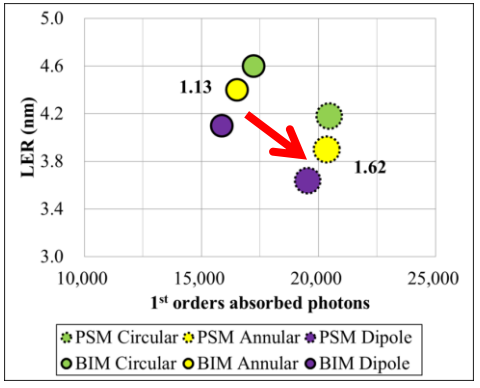


Improved H-V CD Bias, CDU, LER and LWR of the PSM

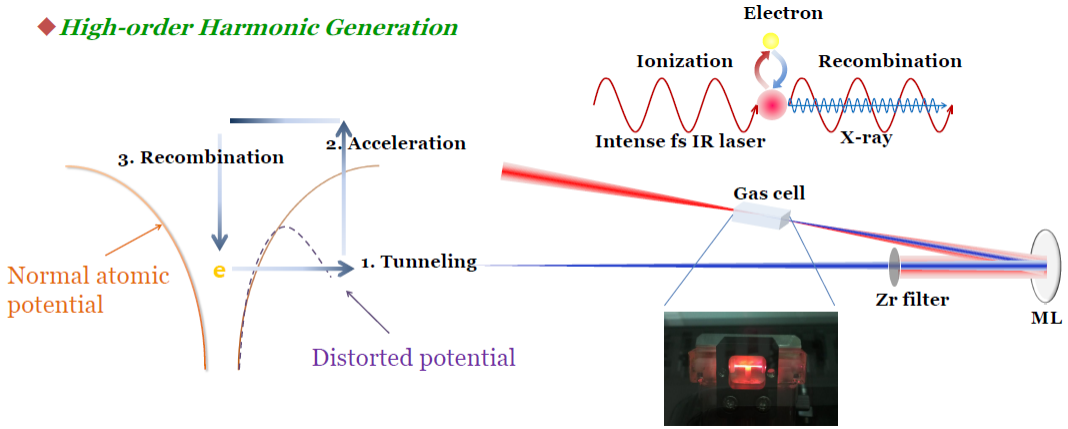


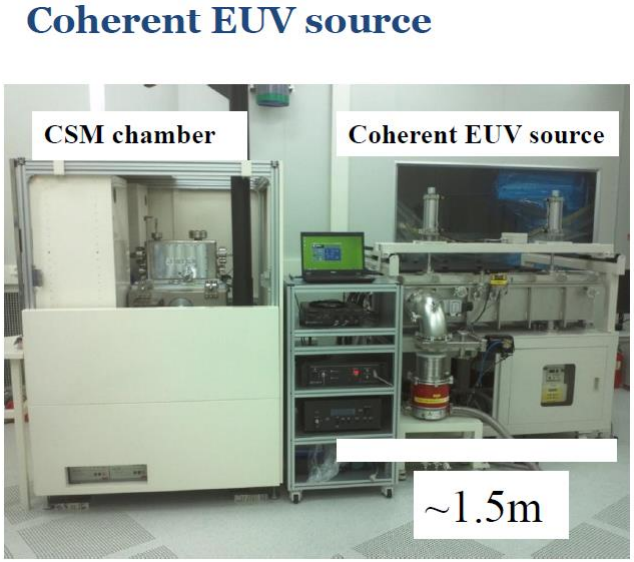
	-1	0	1
BIM	11.45	23.72	11.45
6% PSM	16.37	22.83	16.37
12% PSM	20.55	20.01	20.55

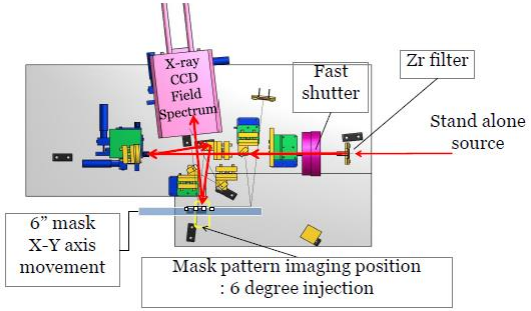


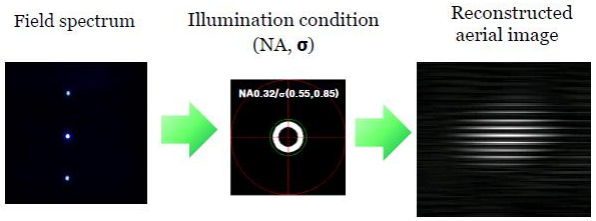


Coherent EUV source for actinic inspection tool (Hanyang University)







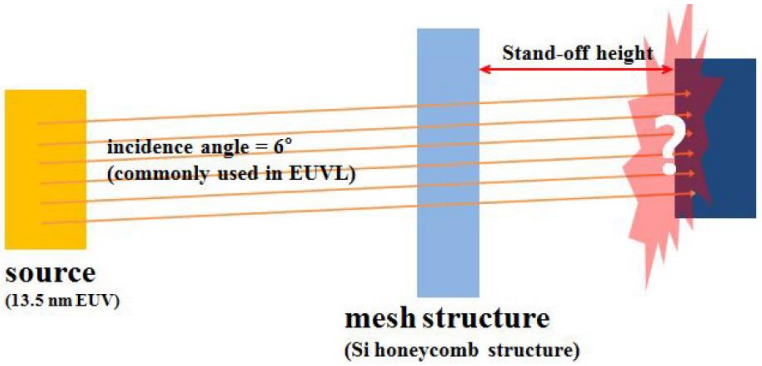


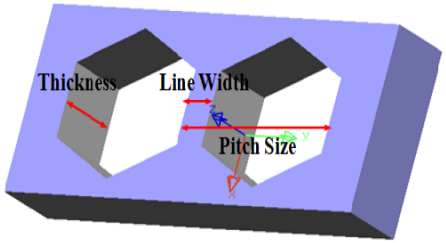
CSM using HHG coherent EUV source

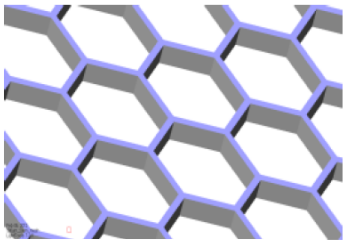
Steady improvements in

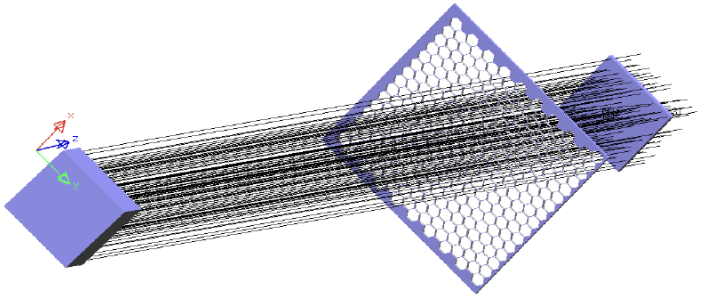
- -Beam divergence
- -Shot-to-shot stability (energy & position)
- -Spectral bandwidth

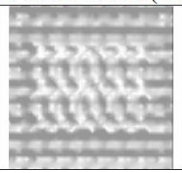
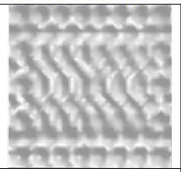
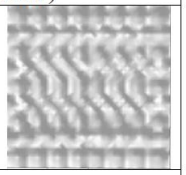
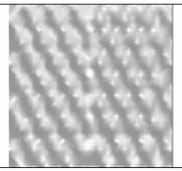
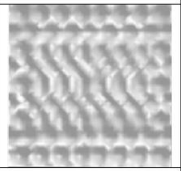
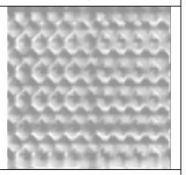
EUV pellicle simulation (Hanyang University)

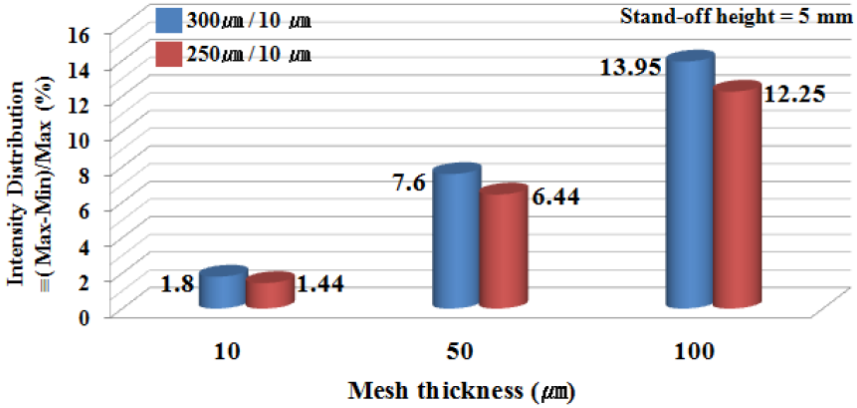


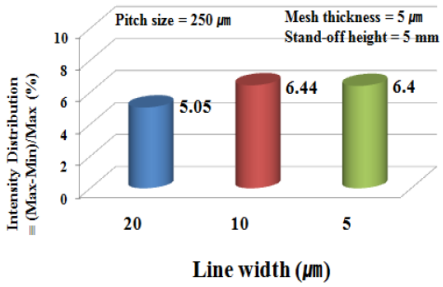


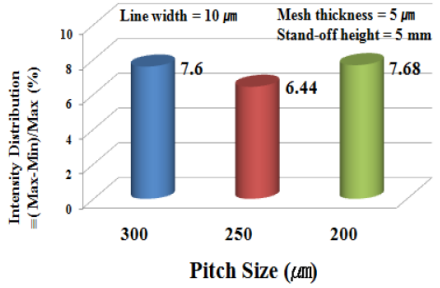




Illuminance distribution (Pitch size & Line width)			
Pitch size = 250 μm			
Line width	20 μm	10 μm	5 μm
Line width = 10 μm			
Pitch size	300 μm	250 μm	200 μm







Intensity distribution of pellicle structure as the function of line width, pitch size, and mesh thickness